Calculations In Chemistry -- Options for 2015-16 (Updated 8/19/15)

Dear AP Instructor,

This is intended to answer questions about the "ChemReview modules," (also known as *Calculations In Chemistry – General Chemistry (Preliminary))* in AP Chemistry. Below describes how you can obtain free copies of the text, how the material may be able to help your program, and how to find funding for the text.

Our project has two goals:

- To help students prepare for higher level science courses, and
- To supply homework that gives instructors more time in class for working problems, labs, demos, and fun activities.

Our materials include 1,250 pages of tutorials that are "lecture notes with clicker questions." As homework, students read the lessons, answer the clickers, and then complete ample practice problems. All problems have fully worked-out answers. Most students find the content far more readable for initial instruction than a standard General Chemistry text. We also provide instructors with frequent, short, editable quizzes that encourage homework completion.

The materials have received favorable reviews from AP Instructors, college instructors, and student users. See www.ChemReview.Net .

AP Use

Cognitive research recommends (see the book Make It Stick), and in our tutorials we include, "quick answer" questions and charts where students write on the page to speed their work. For college students who buy books for class and can write in them, our paperbacks work very well.

We are aware, however, that public high school AP teachers who would like to use the tutorials for homework cannot require students to either purchase books or to write school-purchased texts. In addition, what a public school buys beyond a standard textbook generally must be either "learning software" and/or very inexpensive.

To make the tutorials work for AP, we have produced an inexpensive **EBook** option that

A) can be "written on" where needed, and

B) is very inexpensive (detail below).

We have also collected suggestions from AP instructors that may be able to lower the cost to schools as low as $0 (see below).

A second potential AP downside: One goal of our tutorials is to prepare students to pass *physics* after chemistry -- so they can meet the requirements that apply across science and engineering majors. To get students ready, our lessons include lots of math review to help with scientific calculations of all types.

The new AP curriculum has shifted somewhat away from calculations. We think that using our tutorial homework, AP instructors will be able to prepare students for physics, calculations in all upper-level science courses (including P-Chem), and the specific AP requirements.

Might the tutorials assist you and your students? To decide that, we would suggest:

1. Take a look at the first two chapters of the AP EBook, discussed and posted for free use by students and instructors at: http://chemreview.net/blog/?p=254 . Those two chapters demonstrate use of the green ink "print question" pages for quick answers.

   Those two chapters might be assigned a part of a quick review in AP, either first week or in a summer packet. Parts of those two chapters might be useful as homework assignments in Chem One.

2. A "Hess's Law " lesson posted at www.ChemReview.Net/HessLawSample2.pdf should give you a better idea of the later tutorial content.

3. If you would like to see our complete tutorials in EBook format and/or paperback versions, send an email to W. W. Norton at:

   highschool@wwnorton.com

   Tell them your name, school, district, course(s) you teach, and

   I would like to request inspection copies of the following W.W. Norton texts:

   Calculations In Chemistry for AP/Gen Chem: Modules 1-16 (ISBN 978-0-393-12552-8)

   Calculations In Chemistry – AP/Gen *EBook*: Modules 1-39 (ISBN 978-0-393-92222-6)

   If they don't get back to you quickly, let us know at ChemReviewTeam@ChemReview.Net .

   Even if you find the tutorials not practical in your situation, you may find the problem-solving tips and strategies in the text helpful.

Cost Considerations:

To keep costs low, our printed books are black-ink paperbacks.

For the printed paperbacks, the AP/General Chem tutorials are in three volumes, each separately available from W.W. Norton at $22.50.

All of the 39 AP/General Chemistry modules (chapters) are also available from Norton as an *EBook* for $30 with a 365 day license that can be timed to allow for "summer packet" use.

Paying For AP Use

After the posted 2 free chapters, to give public school students access to the tutorials, below are some options that can help with cost.

1. "Access numbers" for the *EBook* from WW Norton allow student use for 365 days at both home and school. Use can be timed to begin June 1 for "AP summer packet" assignments.

2. The EBooks with "print pages," work well. However, most students find that the "paperback versions" of the lessons are more convenient. If you suggest to students or parents that the paperbacks are an option, quite a few AP parents will buy the $22.50 Volume One to try it out, and then buy Vols. 2 and 3 when it works. A note home to parents on the options, and/or a brief mention at "Back To School Night," may help.

Each one-year EBook license costs $30; 25 licenses would cost $750. However, with the printed book, students do not need the EBook. In practice, this means that the school needs to provide EBook licenses only for AP students whose parents do not buy the books.

Students might share access numbers early during summer packets, or in the fall after accessing the first two free chapters posted online. As some parents buy the paperbacks, usually the EBook access numbers can be re-shuffled to provide "one per student" who does not buy the paperbacks.

3. Ebook "access numbers" often can be purchased from budgets for "software" or "blended learning" as well as textbooks.
4. Contributions to fund paperbacks for students with financial need can often be obtained by talking to:
    - Your local school "STEM partner" or "business partner," or
    - The 'community relations" staff at local hospitals or technology or health care firms. Businesses will often support instructor efforts to help students in "hard to fill" STEM fields.
5. If your school or district has staff who help with "grant applications," check what might be available.

Book and Ebook Order Information

Data on book orders is posted at www.ChemReview.Net/BookInfo.htm

Because there are several books and EBooks with similar titles, be sure to refer to ISBN numbers when dealing with reps and ordering.

In Class and Sub-Day Use

One "class set" of the paperbacks can be combined with EBook access. This allows students to start homework in class out of the paperbacks at the end of a block, then finish in the ebook at home.

The "green ink question print pages" in the EBook can be copied and handed out for an in-class assignment to turn in, with the longer problems to be done on notebook paper and attached.

The class set paperbacks can also be used for "sub plan" assignments such as: "Use the books in class to complete Lesson X, hand in the answers to the problems in Lesson X at the end of class, copy and hand in any problems you do not finish tomorrow."

On days you must be out, many of the AP tutorial lessons on *introductory* topics can also be used with first-year classes in this same manner.

Additional Resources

A. At www.ChemReview.Net/CogSciForChemists.pdf we have posted a paper summarizing cognitive research on how the student brain solves chemistry problems. Included is a listing of four short (non-book) summaries of the new science of learning.

   Post 10 at our blog (http://chemreview.net/blog/?p=321) includes a description and links to additional short articles on cognitive science related to chemistry education.

B. Editable quizzes covering all of the tutorial content are emailed to instructor using the materials on request. A collection of challenging and interesting problems based on the tutorial methods and content that can be worked in class (prepared by Dr. JudithAnn Hartman at the Naval Academy) is also available.

C. W. W. Norton has published a 560 page paperback version of the lessons aimed at students *preparing* for General/AP Chemistry. The text was recently reviewed in the ACS Journal of Chemical Education: http://pubs.acs.org/doi/pdf/10.1021/acs.jchemed.5b00279

   For AP Chemistry, we recommend the full 1,250 tutorial pages, but the review may be helpful in evaluating the methodology utilized in both texts.

D. The use of the tutorials to "flip" parts of AP/General Chemistry are discussed here: http://confchem.ccce.divched.org/2014SpringConfChemP2

   and on Slides 8 to 13 here: http://www.chemreview.net/BCCE2012Math.pdf

If we can answer questions or help in any way, please contact us at ChemReviewTeam@ChemReview.Net .

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Some of the options suggested and used by AP instructors include:

Our findings and premises were:

1. Data show that student math computation skills have declined significantly over the past 20 years.
2. We can provide needed math review, the content of General/AP chemistry, and have time in class for activities that build conceptual understanding, if we transfer parts of traditional lecture content to homework.
3. During homework, students need a "textbook" specifically designed to support initial learning, plus a quiz system that encourages homework completion.
4. If we align our methodology with recent recommendations from cognitive science, we can make class learning and homework more efficient and effective. .
5. Materials beyond the regular textbook that we ask students to use must be very inexpensive.

For several years, all of the lessons were given away for free online. Students and instructors found them very helpful. Professors then asked for printed book versions, which were more convenient for students. However, trying to research, write, test, correct, self-publish, and deal with bookstores proved to be un-managable and costly.

Publisher W. W. Norton offered to professionally review, edit, and publish a 560 page textbook/workbook version of the lessons aimed at students *preparing* for college General Chemistry. The book and methodology recently received a very nice review in J Chem Ed (http://pubs.acs.org/doi/pdf/10.1021/acs.jchemed.5b00279).

With a larger group of co-authors, we are working on similar lessons that cover AP/General chemistry, and we are looking for other instructors who would contribute by adding to and evaluating the materials. A "beta" 1,250 pages is being tested at several colleges, distributed (but is not yet "published") by WWNorton.

In college use, the beta books have gotten measurably very good results, primarily because the recommendations from the new cognitive studies work very well. But to work efficiently as homework, in places students must write in these books. College students buy their books, so that's not a problem.

But AP teachers who would like to use the lessons can't require students or parents to purchase workbooks, most schools won't buy expendables that students write in, and whatever the school buys beyond the AP textbook must cost close to $0.

To make the lessons work in AP, oOver the past year, we have working on a Printed/EBook combo that A) can be "written in" and B) is very low cost (detail below). We are also collecting options suggested by AP instructors that we think in many cases will lower the cost to the school to $0.

The two year EBook license costs $30/license times 25 AP students = $750 per section, but w

There are reasons that our materials may not work in your situation. Having taught AP –thought back in the 80's (I'm a dinosaur) when the program was very different – let me suggest a few.

Our tutorials are designed as homework, and in college chem, with a system attached to "encourage" homework completion, we have generally had fantastic results. But college kids are in class ~18 hours a week, and have a library on campus for quiet study. AP students are in class ~30 hours a week, tend to have more extra-curriculars, and may not have a great study space in the evenings. And if your district lets them take 3 other AP courses along with AP chem, homework time for chem may be an issue.

Then again, AP teachers often have students in class for close to 5 lecture hours a week, whereas for professors it's about 3. Some of our lessons can be done in class at the end of a long block, or the material can be integrated into lecture. How would this work out? You be the judge.

Our materials are cheap and college professors simply tell students to buy them. AP instructors may be able to recommend parents buy a help book for students, but in K-12, required materials must generally be supplied by the school district, and then any cost is a problem.

We have designed an EBook version of our 1,250 page tutorials that we think will be workable for AP, and the cost is 60% less than the printed books our colleges users have asked for. To use the book, the student or the instructor over the year prints about 100 pages where the student fills in blanks or charts or answers short questions.

when it was
. that currently covers many Judy Hartman from the Naval Academy
We are looking for help in two areas. But the first favor we would ask would be for you to review some materials and give an evaluation of whether they might be useful in your particular teaching situation.

The longer term goal of our group, beside adding topics to the materials we have, is to gather into a booklet for instructors a variety of tested, proven activities that fit into a class period: Challenging questions, demonstrations, and mini-labs that can be done inside 45 or 80 minute periods that are fun, useful, and build understanding.

But

To start, we have written 1,250 pages of Gen/AP chem "student homework tutorials" based on these premises and seen these results:

1. The current generation has difficulty in quantitative sciences because for the past 20 years, K-12 math standards have de-emphasized computation and essential mental math. By reviewing these topics in chem just before they need them for a chem topic, we have seen chem success rates improve.
2. To cover both math review and the content of General/AP chemistry in 2 semesters, we need to transfer parts of the delivery of traditional lecture content to homework. To do that, students need a "textbook" that they can read with comprehension, specifically designed to support *initial* learning. We have drafted an experimental text that tries to do that, and in college chem classes it is getting very good results.

3. Getting students to do homework on a regular basis takes some persuasion. We have written frequent short editable quizzes that encourage homework completion. Existing online homework systems, if available, can also help.
4. To come out of this with more science majors, initial chemistry must be interesting, successful, and fun. By moving part of traditional lecture to homework, we have given instructors more time for labs, demonstrations, discussions, and working with students on tough but interesting problems. We have started a collection of activities, but this area needs lots of work.
5. For any of this to work, we need to align methodology with recommendations from cognitive science on how to make in class and homework more efficient and effective. Part of that is to be honest with students about the need to memorize new facts and algorithms and practice their application. We do that in our tutorials and have seen very good results.
6. Providing extensive instructional materials involves some costs, *but* anything in addition to the textbook must be cheap for college students and incredibly cheap for K-12 use. Our materials come in cheap paperbacks that have worked at the college level. We have a very cheap EBook format we *think* will be a good option for AP.

Some of our success at the college level is documented on slides X to X here:

http://www.chemreview.net/BCCE2012Math.pdf

and in our flipping paper here: http://confchem.ccce.divched.org/2014SpringConfChemP2

But AP is a bit different from college chem.

We tried applying those recommendations, tweaked based on the results, and over several years got a system that works very well.

As a part of the approach, we wrote 1,250 pages, in paper and ebook formats, of AP/General-level tutorials that transfer *part* of lecture and problem solving practice to homework. This takes pressure of the instructor to cover so much in lecture, providing more time in class for student work with feedback and guidance from instructors, which is one of the strategies cog sci recommends.

The strategy was recommended by cognitive studies: Type your lecture notes, use "completion questions" to scaffold explanations, add clicker questions every few pages to force them to think about what they read, keep sections short, encourage them to begin memorization of the rules before they do some practice problems, supply fully worked out answers, give frequent short quizzes to drive homework completion. And for us, this science-recommended method has both produced very good results and provided time to try some instructional experiments in class.

The first two chapters of the AP book are posted for free use, and suggestions for their use is posted here: http://chemreview.net/blog/?p=254

Part of those two chapters might be useful in a sequence of homework assignments in Chem One; all might be assigned a part of a quick review of Chem 1 in AP Chem as part of a summer packet or first week.

I have attached two files from our kinetics chapter that are more typical of the AP topics.

The self-study process and the ebook "print page" methodology takes a while to explain in the beginning, but after that we have had very good results with the approach.

That said, if the structured methodology of the text drives you nuts, it's good to find out early.

2. If you think the full book might be intriguing, I'd suggest: Send an email to the publisher of our textbook (W. W. Norton) at:

highschool@wwnorton.com

Tell them your name, school and district, course(s) you teach, and then

I would like to request inspection copies of the following Norton texts:

Calculations In Chemistry for AP Chem: Modules 1-16 (ISBN 978-0-393-12552-8)

Calculations In Chemistry -- AP Chem *EBook*: Modules 1-39 (ISBN 978-0-393-92222-6)

Hopefully you will get a response pretty quickly, but that will be your first Monty Python experiment. As a high school instructor, one of your few perks is the ability to request texts to consider for adoption, and this should go smoothly, buuuuut sometimes it has taken longer than it should. And we would like to know how quickly they are responding this year to AP requests (Norton is a "college focused" text publisher but says they want to include the AP instructors among those they serve.)

Even if you don't find the books possible or desirable to use in class, I think you will find the problem-solving tips and strategies to be of interest.

3. Online at www.ChemReview.Net/CogSciForChemists.pdf we have posted a paper summarizing cognitive research on how the student brain solves chemistry problems. Even if the method in our materials does not strike your fancy, my suspicion would be that everyone's teaching will likely benefit from comparing our personal experiences to what the research says should work.

In that article are 6 other references, four of which are short (non-book-length) summaries from various perspectives on the new learning science. You might find those to be good summer reading.

Post 10 at our blog (at http://chemreview.net/blog/?p=321) includes articles by topic by Dan Willingham. I'd suggest trying one or two of those as well on topics that tweak your interest.

4. The AP text comes in 3 volumes, and you ask above to see Volume One in print and all 39 chapters of the EBook. Let me tell you about the books, and then some options for obtaining them at minimal cost to the school.

Good news: The books were used as the primary source of homework in Engineering Chem at Rowan University (in NJ) and got fabulous results. Some engineering students in sections that used the books "complained" sheepishly a year later that they were finding engineering easy but their buddies who had been in other sections were not.

The instructor (Don Dahm) wanted a way to get more time in class for more discussions, demos, and problem solving, and the books gave him that. ACS Gen Chem Exam scores hit the 64th percentile teaching Gen Chem on the schedule of a one-semester course. For additional detail, see here:

http://confchem.ccce.divched.org/2014SpringConfChemP2

We give users with homework that works, a bank of frequent short modifiable quizzes on the lessons to "encourage" homework completion, and challenging problems that go "beyond the lessons" (from Dr. Judy Hartman at the Naval Academy).

Less Good News: The books have worked pretty well, but not as well, for the "non-engineering chem" students at Rowan and elsewhere. In the books, we reviewed exponentials, graphing, logarithms, but assumed the kids could do arithmetic and algebra fundamentals. What we found was that more kids could not do simple mental arithmetic and simple algebra than we thought (the engineering school kids were above average), and that the math fluency was more important than we thought. Subsequent research that we have found explained that. We will talk below about how we hope to address that problem so that even kids with backgrounds that de-emphasized math fluency in fundamentals can excel.

5. AP specific issues:

a. Our material, to keep cost and page count down, focused on calculations. We omit topics that are color-graphics intensive and regular texts do well. I'd guess that we cover more than half of the topics in nearly all AP and Gen Chem, but use of a standard text for some topics, reading, and homework problems will still be necessary on occasion. After doing the reading and problems in our homework lessons, they will find the Gen Chem reading more comprehensible and even the more difficult problems more doable. They will be very good problem solvers.

b. The AP course is of course drifting away from a calculation focus. That said, we think that with well-structured readings and homework, you will have more time in class to cover other specifics the AP test wants. And using our lessons, we suspect your kids will thank you when they get to P-chem and physics and the engineering many students are aiming for, where I fear the AP calculation de-emphasis may lead to problems. I don't see the colleges de-emphasizing calculations in the quantitative sciences.

6. The Cost

Our material is inexpensive, but any cost in K-12 is a problem. If you'd like to experiment with the materials, here are some options.

The 39 chapters of the AP lessons are in

- Three paperback volumes @ $22.50 each = $67.50 for the 3 volume set, or
- A complete Ebook with a 2 year license costing $30 each.

If you'd like to try the lessons, I'd recommend trying to find funds for 12 EBook licenses for your single AP section. $12 x $30 = $360

Why 12?

The EBooks work well, BUT writing in and using the printed volumes is more convenient than working off the screen. If you give AP parents the choice of using the EBooks on the school license for free, or buying that first printed volume for their kid, over half will buy the first book if you recommend it as a choice (but not a requirement). The paperbacks are free shipping from Norton if 3 books are bought by one parent or 3 or more kids order Volume One together. And the parents will buy the remaining two by November 1 after they see how the first one works.

The first two chapters are free online for everyone. After those, a class of 24 might need to share a license for a few days until their books come in. After that, you'd likely have 12 or more using printed books and less than 12 using the licenses.

It might be a bit of a hassle at the starts, but I'll bet it would work out well.

ToTom02a

Tom –
Let me see if I can give you a brief overview of our Monty Python work, and then suggest some steps that if started early may help with prep for AP and Chem I next year.

First, the scientific foundation.

Your observation was, "The more years I teach the more I am convinced that before students can truly investigate in a scientific manner they need a strong foundation of factual and procedural knowledge." That's what Don, Judy, and I thought when we started our project, too.

We have changed our view to some extent. We would now say:

"before students can truly investigate in a scientific manner they need a REALLY REALLY strong foundation of factual and procedural knowledge, AND EVEN MORE KINDS OF KNOWLEDGE THAN WE THOUGHT."

We have come to that conclusion first via our results, and then via research on how the brain works. In the 2008 NMAP Report, on page 4-5, cognitive experts Geary et al. wrote,

> "At all ages, there are several ways to improve the functional capacity of working memory. The most central of these is the achievement of automaticity, that is, the fast, implicit, and automatic retrieval of a fact or a procedure from long-term memory…. [For example], to obtain the maximal benefits of automaticity in support of complex problem

> solving, arithmetic facts and fundamental algorithms should be thoroughly mastered, and indeed, over-learned, rather than merely learned to a moderate degree of proficiency."

"Over-learned" is cognitive jargon for broken into component parts that are then memorized to the point of *perfect* recall – *repeatedly*. How strong the foundation needed to be was surprising.

As well as how much. In our original program, we focused on giving students review of algebra topics needed to solve chem problems – just before they needed it. And that worked incredibly well for the kids in Don Dahm's engineering chem at Rowan U.

The bad news was we came to find that for the kids who had not been admitted to the engineering school, they lacked automaticity in both algebra and arithmetic fundamentals. What we were doing helped, but especially helped, we found in testing, as students had stronger mental math skills. And in some groupings, not many did.

The good news is that although we don't like the ideal of having to require kids in 10^{th} grade and up to learn their times tables for often the first time, we have good indications that if we push them to get better get at mental arithmetic toward the start of chem, they see the quantitative relationships and solve the calculations quite well, and they learn to do so more quickly.

That's the theory, and for us it is working better and for more kids with each tweak.

Second scientific finding: Students do need to initially memorize in a topic, but they then need lots of interesting practice in applying what they have recently memorized, in problems, demos, discussions, inquiry, labs, active learning in general.

In practice, we have found we can push some of the lecture content learning and practice to homework in HS chem, and more in AP/Gen Chem, freeing more time in class for experiments with active learning.

What applies to math applies to chem and physics and any rule-based discipline.

There is also agreement on what information must be automated. Daniel Willingham (Am. Ed. 2004) writes,

> "In each field, certain procedures are used again and again. Those procedures must be learned to the point of automaticity so that they no longer consume working memory space. Only then will the student be able to bypass the bottleneck imposed by working memory and move on to higher levels of competence."

For additional detail, see: at www.ChemReview.Net/CogSciForChemists.pdf

I teach College Prep Chemistry (1 section), Honors Chemistry (4 sections), AP Chemistry (1 section).

From: EANelson <EANelson@ChemReview.net>
Sent: Thursday, June 11, 2015 8:12 AM
To: Hanninen, Tom
Subject: RE: Thanks and a collaboration proposal

Tom -Welcome to the MP group!
I'm finishing up some edits on some "first two weeks" material and will ship it in the next few days.
This is all experiment and options, but I think you'll be happy with the outcome And students have been as well.

First questions:
Next year, how many different levels of chem will you be teaching? All AP or a mix?
In chem 1, are there different groupings, and about what % of students passing through take each?

-- rick

-----Original Message-----
From: Hanninen, Tom [mailto:thanninen@ldsd.org]
Sent: Wednesday, June 10, 2015 4:48 PM
To: EANelson@ChemReview.net
Subject: RE: Thanks and a collaboration proposal

That would be great Rick.

I'd love to participate. The more years I teach the more I am convinced that before students can truly investigate in a scientific manner they need a strong foundation of factual and procedural knowledge.

Let me know how I can help.

-Tom

From: EANelson <EANelson@ChemReview.net>
Sent: Wednesday, June 10, 2015 12:05 PM
To: Hanninen, Tom
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Tom -

I appreciated your kind words on the AP Chem bulletin board about the algorithmic learning issue.

I am involved with a small group of high school and college faculty who are trying to improve student success rates in initial chem courses. Since that for us is the holy grail, we call ourselves the "Monty Python group."

Our focus has been helping students learn to solve calculations, since we all felt that the calculations in General/AP chem were where students had the most difficulty.

We also felt that a major purpose of first-year chem was to help kids get ready not just for P-chem, but for the calculations of the engineering and health fields which most of our students are hoping to work, and where jobs tend to be.

The AP designers have shifted their test away from calculations to some extent (how much may not yet be clear, and may be subject to change), but we still think helping combining the qualitative and quantitative sides is what students will need to prep for their upper level science courses. To the extent the AP test gets away from the quantitative, personally I think it diminishes what in the past has been a great curriculum to prep students for science.

Long and short: we have some materials that we are experimenting with that are designed to help students improve their quantitative understanding and problem-solving skills in both "honors HS" and AP-level chem. The goal is "prep for college science." We are looking for instructors willing to evaluate them and then perhaps test their use with students at both levels.

The material is still in "beta-version," but if you might be interested in joining in some work to see if we can improve chem results by improving math skills needed for chem, I would be happy to send some packets along for your summer review.

-- EA (rick) nelson

Hanninen –

Tom Hanninen's Profile

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-- EA (rick) nelson

(lecture notes with clicker questions, stress initial memorization, have them work completion problems, teach consistent problem solving algorithms, give short quizzes

1. We would like to provide you with a free copy of what we have done so far on the Gen/AP materials, in print and Ebook, and ask you to evaluate if these lessons might be useful in your setting.
2. If you'd like to experiment with the homework lessons, we will send you an updated list of suggestions from AP instructors on ways to ways to obtain the materials at little to no cost to your school.

Eric,

I've been reading a lot of your links from your website and am very intrigued.

Thanks for posting - you've given me a lot to think about over the summer. I get good results from my students but not great. I've been looking for methods and strategies help my students, especially my struggling ones, become better thinkers and much of your infrmation focues on that.

Thanks,

Tom